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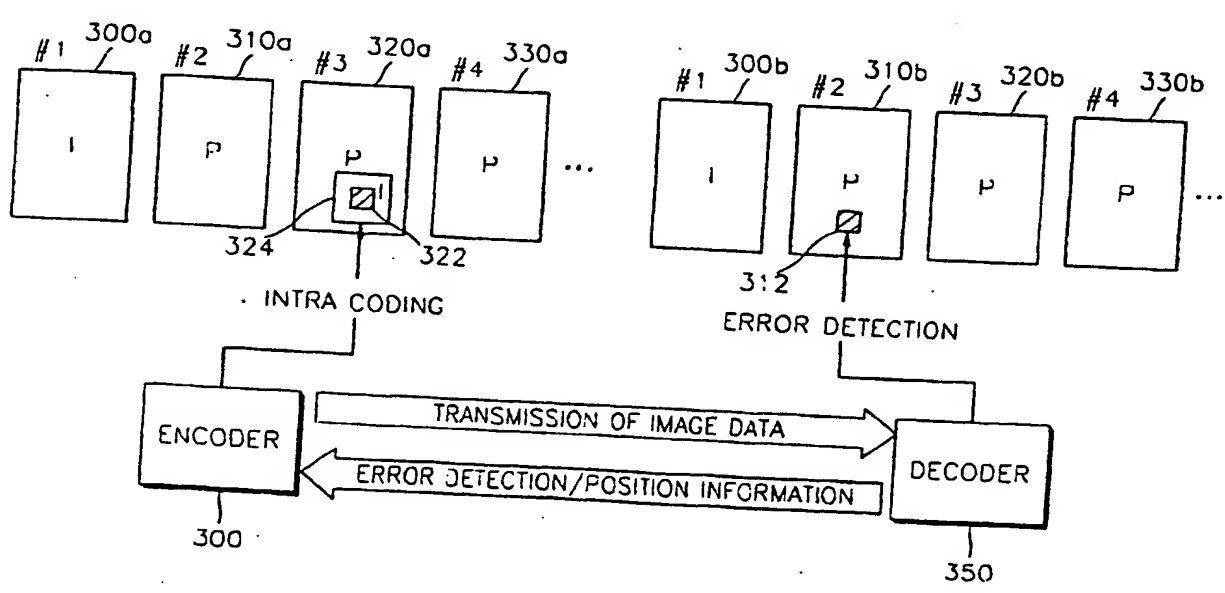
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(54) **Method for inhibiting error propagation in digital image data communication system**

(57) When an error is detected by a decoder (350), it is fed back to an encoder (300), and the encoder uses a technique of compulsorily intracoding (424) an erro-

neous block (322) and the search range (324) of the block with reference to feedback information, thereby inhibiting error propagation in a digital image data communication system.

FIG. 3



EP 1 120 966 A2

## Description

[0001] The present invention relates to an image data communication system, and more particularly, to a method of inhibiting error propagation in a bidirectional digital compressed image data communication system.

[0002] Figure 1A is a schematic diagram illustrating one way of configuring a bidirectional digital image data communication system. In Figure 1A, two nodes 100a and 150a, which are connected to each other via a communication network, include encoders 102a and 152a, respectively, and decoders 104a and 154a, respectively, and communicate with each other via a bidirectional communication channel.

[0003] Figure 1B is a schematic diagram illustrating another way of configuring a bidirectional digital image data communication system. In Figure 1B, a node 100b includes only an encoder, and another node 150b includes only a decoder. In this case, image data is only transmitted from the node 100b having an encoder to the node 150b having a decoder via a forward channel. A backward channel is used to transmit feedback information on the image data received via the forward channel. Of course, a bidirectional digital image data communication system can be configured by the combination of Figures 1A and 1B.

[0004] In an image data communication system, image data undergoes data compression and decompression to effectively use the bandwidth of a communication channel. That is, an external video signal is compressed during encoding by the encoder 102a, 152a, or 100b and transmitted via a communication network. The encoder 104a, 154a, or 150b decompresses the received compressed image data to restore the original image data during decoding, and outputs a restored video signal.

[0005] Figure 2A is a schematic diagram illustrating a way of encoding each image frame in a digital image data communication system.

[0006] The way of encoding an image frame includes intracoding and intercoding. Intracoding is encoding an image frame using the correlation between pixels within a screen, and intercoding is encoding a current image frame with reference to the previous frame (or the next frame) using the correlation between screens. An image frame encoded by intracoding is referred to as an I frame, and an image frame encoded by intercoding is referred to as a P frame. When an image frame is encoded with reference to the next image frame, it is referred to as a B frame. Hereinafter, the term P frame is used to refer to any intercoded frame, including a B frame.

[0007] Inter coding generally has a high compression efficiency, so that most image frames are encoded by intercoding using the correlation between frames. That is, as shown in Figure 2A, the first image frame 200a in a sequence is encoded by intracoding to constitute an I frame, and the subsequent image frames 210a, 220a,

230a and 240a are encoded by intercoding to constitute P frames, until the corresponding sequence is ended.

[0008] However, this intercoding method using the correlation between frames has a problem of error propagation. Figure 2B is a schematic diagram illustrating a conventional error propagation mechanism in a digital image data communication system.

[0009] As shown in Figure 2B, it is assumed that the first and second frames 200b and 210b in a sequence have no errors, while the third frame 220b has an error 222 at a specific block. If the intercoding method is used, the fourth frame 230b is encoded with reference to the third frame 220b, so that the error 222 in the third frame 220b is propagated into an error 232 in the fourth frame 230b. Similarly, the fifth frame 240b has an error 242 propagated from the error 232 of the fourth frame 230b.

[0010] That is, in the intercoding method, if an un-restorable error is generated at a specific block on a frame during transmission or for other reasons, it is not limited to the corresponding frame but affects the subsequent frames. Also, this propagated error is gradually magnified, since each block in a current frame is encoded with reference to both a corresponding block in the previous frame and its adjacent blocks in the intercoding method.

[0011] Various mechanisms have been designed for inhibiting the error propagation caused in the intercoding method. Figure 2C is a schematic diagram illustrating a conventional error propagation prevention mechanism in a digital image data communication system.

[0012] In Figure 2C, the I frame 200c is obtained by intracoding, and specific blocks 214, 224, 234, 244 of P frames 210c, 220c, 230c and 240c, respectively, obtained by intercoding, are compulsorily encoded by intracoding. A current recommendation is that an I block (which is a block compressed by intracoding) be included at least every 132 image frames, but a detailed method of selecting the I block is not prescribed separately.

[0013] In the intercoding method, encoding is performed using the correlation between frames, so that both a previous frame and a current frame are referred to during encoding, and a process such as discrete cosine transformation (DCT) for encoding includes a floating point operation. Of course, decoding also includes a similar floating point operation. However, the results of the floating point operations of an encoder and a decoder may have a slight difference depending on the type of the corresponding system. Thus, in order to prevent accumulation of this slight difference, inclusion of one I block at least every 132 image frames has been recommended.

[0014] The technique of compulsorily intercoding a specific block as shown in Figure 2C prevents the propagation of an error which is caused by the difference between the result of floating point operation of an encoder and that of a decoder. However, this technique cannot fundamentally prevent propagation of an un-restorable error that occurs during transmission or for

other reasons.

[0015] Of course, a decoder minimizes an error recognized by a person while visually watching images, using a technique such as concealment, when an un-restorable error is detected from a specific block on a received image frame. However, this technique cannot fundamentally correct an error, so the conventional intercoding method cannot prevent an error from being propagated from a frame to another frame.

[0016] An aim of the present invention is to provide a method of processing transmitting/received data to reduce and preferably prevent error propagation in a digital image data communication system.

[0017] According to the present invention there is provided a method of processing transmission data to inhibit error propagation in a digital image data communication system, comprising (a) inputting an image frame from an external source; (b) checking for feedback error information including the location of an erroneous block on a compressed image frame detected during decoding by a decoder, the feedback error information received via a communication network; (c) if it is determined in step (b) that there is feedback error information, intracoding an erroneous block, the location of which is included in the feedback error information, and its search range, which is referred to to encode the erroneous block using an intercoding method, among the image frame input in step (a), thereby constituting a compressed image frame; and (d) transmitting the compressed image frame constituted in step (c), via a communication network.

[0018] Preferably, the error block location included in the feedback error information in step (b) is set in units of 16 (pixel)×16 (pixel) macro blocks.

[0019] It is also preferable that the search range in step (c) includes 16 pixels or 32 pixels in four directions on the basis of the erroneous block.

[0020] Preferably, the feedback error information in step (b) is associated with the image frame immediately preceding a current image frame.

[0021] Also according to the present invention there is provided a method of processing transmission data to inhibit error propagation in a digital image data communication system, comprising (a) inputting an image frame from an external source; (b) when the image frame input in step (a) is the first image frame in a specific sequence, encoding the entire image frame using an intracoding method, to constitute a compressed image frame; (c) when the image frame input in step (a) is not the first image frame in a specific sequence, checking feedback error information including the location of an erroneous block on a compressed image frame detected during decoding by a decoder, the feedback error information received via a communication network; (d) if it is determined in step (c) that there is feedback error information, intracoding an erroneous block, the location of which is included in the feedback error information, and its search range, which is referred to to encode

the erroneous block using an intercoding method, among the image frame input in step (a), while the remaining area is encoded by intercoding, thereby constituting a compressed image frame, and if it is determined in step (c) that no feedback error information is received, intracoding block(s) selected by a predetermined method from among the blocks of the image frame input in step (a), and intercoding the remaining blocks, thereby constituting a compressed image frame; and (e) transmitting the compressed image frame constituted in step (b) or (d), via a communication network.

[0022] Also, a method of processing received data to inhibit error propagation in a digital image data communication system, according to an aspect of the present invention, includes: (a) receiving a compressed image frame via a communication network; (b) decoding the compressed image frame received in step (a) to constitute an image frame; (c) if an error is detected at a specific block on the compressed image frame received in step (a) during the decoding in the step (b), sending feedback error information including an error block location back to an encoder via a communication network; and (d) outputting an image frame restored in step (b).

[0023] Further, the present invention provides a computer-readable recording medium for recording a program which is executed in a computer for processing transmission data to inhibit error propagation in a digital image data communication system, according to an aspect of the present invention, wherein the program includes the steps of: (a) inputting an image frame from an external source; (b) checking feedback error information including the location of an erroneous block on a compressed image frame detected during decoding by a decoder, the feedback error information received via a communication network; (c) if it is determined in step (b) that there is feedback error information, intracoding an erroneous block, the location of which is included in the feedback error information, and its search range, which is referred to to encode the erroneous block using an intercoding method, among the image frame input in step (a), thereby constituting a compressed image frame; and (d) transmitting the compressed image frame constituted in step (c), via a communication network.

[0024] According to another aspect of the present invention, a computer-readable recording medium records a program which is executed in a computer for processing transmission data to inhibit error propagation in a bidirectional digital image data communication system, the program including the steps of: (a) inputting an image frame from an external source; (b) when the image frame input in step (a) is the first image frame in a specific sequence, encoding the entire image frame using an intracoding method, to constitute a compressed image frame; (c) when the image frame input in step (a) is not the first image frame in a specific sequence, checking feedback error information including the location of an erroneous block on a compressed im-

age frame detected during decoding by a decoder, the feedback error information received via a communication network: (d) if it is determined in step (c) that there is feedback error information, intracoding an erroneous block, the location of which is included in the feedback error information, and its search range, which is referred to to encode the erroneous block using an intercoding method, among the image frame input in step (a), while the remaining area is encoded by intercoding, thereby constituting a compressed image frame, and if it is determined in step (c) that no feedback error information is received, intracoding block(s) selected by a predetermined method among the blocks of the image frame input in step (a), and intercoding the remaining blocks, thereby constituting a compressed image frame; and (e) transmitting the compressed image frame constituted in step (b) or (d), via a communication network.

[0025] Further, the present invention provides a computer-readable recording medium for recording a program which is executed in a computer for processing transmission data to inhibit error propagation in a digital image data communication system, wherein the program includes the steps of: (a) receiving a compressed image frame via a communication network; (b) decoding the compressed image frame received in step (a) to constitute an image frame; (c) if an error is detected at a specific block on the compressed image frame received in step (a) during the decoding in the step (b), sending feedback error information including an error block location back to an encoder via a communication network; and (d) outputting an image frame restored in step (b).

[0026] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figures 1A and 1B are schematic diagrams illustrating ways for configuring a bidirectional digital image data communication system;

Figure 2A is a schematic diagram illustrating a method of encoding image frames in a digital image data communication system;

Figure 2B is a schematic diagram illustrating a conventional error propagation mechanism in a digital image data communication system;

Figure 2C is a schematic diagram illustrating a conventional error propagation preventing mechanism in a digital image data communication system;

Figure 3 is a schematic diagram illustrating an error propagation preventing mechanism in a digital image data communication system according to an embodiment of the present invention;

Figure 4 is a flowchart illustrating a method of processing transmission data to inhibit error propagation in a digital image data communication system according to a preferred embodiment of the present invention; and

Figure 5 is a flowchart illustrating a method of processing received data to inhibit error propagation in a digital image data communication system according to a preferred embodiment of the present invention.

[0027] In the preferred embodiments of the present invention, it is assumed that, when a decoder 350 detects an error, it can feed the information on the error back to an encoder 300 via a backward channel. Thus, the embodiments of the present invention are applied to the digital image data communication system of Figure 1B and a combination of Figures 1A and 1B.

[0028] As shown in Figure 3, in an embodiment of the present invention, an encoder 300, in principle, encodes the first frame 300a in a sequence using an intracoding method and encodes the subsequent frames 310a, 320a and 330a using an intercoding method. A decoder 350 decodes compressed image data 300b, 310b, 320b and 330b received via a communication channel.

[0029] It will be apparent to those skilled in the art, to which the present invention pertains, that discrete cosine transformation, quantization, variable length encoding, inverse quantization, inverse discrete cosine transformation, or the like is usually used for encoding by the encoder 300 according to an embodiment of the present invention, and that the corresponding inverse transformation is usually used for decoding by the decoder 350.

[0030] The operation of the embodiment of the present invention will now be described on the assumption that the decoder 350 has detected an error from a specific block 312 in the second frame 310b. For example, it is assumed that an error is detected from a specific block by reverse variable length coding (RVLC) or the like. The detected error excludes errors that can be restored by forward error correction. An image frame having this unrestorable error is processed more naturally to a person by a technique such as concealment, and then output.

[0031] In an embodiment of the present invention, when the decoder 350 has detected an error during decoding, feedback error information including the location of a block where the error has been detected, or the like, is transmitted to the encoder 300 via a backward channel.

[0032] The encoder 300 encodes a corresponding error block 322 and a search range 324 of the block by compulsorily using an intracoding method when the next frame 320a is encoded, with reference to the feedback error information received via a backward channel. Here, the search range denotes blocks which are re-

ferred to in order to encode a specific block using an intercoding method.

[0033] Thus, the decoder 350 receives an image frame in which an error-detected block and a search range of the block have been encoded by intracoding, so does not refer to any frames to decode the corresponding block. Thus, an error generated on the previous frame is not propagated. Also, in this embodiment of the present invention, an error is restored or removed within a short period of time by inhibiting error propagation.

[0034] Hereinafter, the processing of image data by the encoder 300 and by the decoder 350 to realize the embodiment of the present invention of Figure 3, will be described in more detail with reference to Figures 4 and 5.

[0035] Figure 4 is a flowchart illustrating a method of processing transmission data to inhibit error propagation in a digital image data communication system according to a preferred embodiment of the present invention.

[0036] First, an encoder receives an external image signal, in step 400. The external image signal is input in units of frames, and an analog image signal must be converted into digital image data before encoding such as discrete cosine transformation is performed.

[0037] Next, it is determined whether the input image frame in step 400 is the first image frame in a specific sequence, in step 410. Here, a sequence denotes a group of a series of screens having the same property, the group being used at the uppermost layer in a data hierarchy structure in image data communications.

[0038] If the input image frame in step 400 is the first image frame in a specific sequence, the entire image frame is encoded by intracoding to constitute an I frame, in step 412. Compression of an image frame during this encoding has already been described.

[0039] If the input image frame in step 400 is not the first image frame in a specific sequence, feedback error information received from a decoder via a communication network is checked, in step 420. Here, the feedback error information includes the location of an erroneous block on a compressed image frame detected during decoding by a decoder. In the case when the input image frame is the first image frame in a specific sequence, the entire image frame is encoded by intracoding, so the feedback error information does not need to be checked.

[0040] Preferably, the erroneous block location included in the feedback error information is set in units of 16 (pixels)  $\times$  16 (pixels) macro blocks, since the basic unit of a motion vector used for intercoding is a macro block.

[0041] Also, preferably, feedback error information, which is referred to to encode a current image frame, is associated with the image frame immediately preceding the current image frame, since as much error propagation as possible within a range allowed by the bandwidth

of a communication channel can be inhibited.

[0042] If no feedback error information is received from the decoder, the image frame input in the step 400 is encoded and/or compressed in a conventional way, in step 422. That is, blocks selected in a predetermined way, among the blocks of the image frame input in step 400, are compulsorily encoded by intracoding, and the remaining blocks are encoded by intercoding, thereby forming a compressed image frame (which corresponds to a P frame on the whole). Here, blocks to be encoded compulsorily by intracoding can be selected in an appropriate way within the range of the current recommendation that one I block is included at least every 132 image frames.

[0043] If there is feedback error information received from the decoder, an error block included in the feedback error information, and its search range from the image frame input in step 400, are encoded by intracoding, while the remaining area is encoded by intercoding, thereby forming a compressed image frame (which corresponds to a P frame on the whole), in step 424. Here, the search range denotes an area which is referred to in order to encode a particular block by intercoding, as described above, and is set during the negotiation in the initial step between an encoder and a decoder. In general, it is preferable that a search range includes from 16 pixels in four directions from a specific block, that is, 9 macro blocks including the corresponding block, or includes 32 pixels in four directions from a specific block, that is, 16 macro blocks including the corresponding block.

[0044] Finally, a compressed image frame constituted through the step 412, 422 or 424 is transmitted via a communication network, in step 430.

[0045] Up to now, a method of processing transmission data in an encoder according to an embodiment of the present invention has been described. Now, a method of processing received data in a decoder according to an embodiment of the present invention will be described.

[0046] Figure 5 is a flowchart illustrating a method of processing received data to inhibit error propagation in a digital image data communication system according to a preferred embodiment of the present invention. First, a decoder receives a compressed image frame via a communication network, in step 500. Here, the compressed image frame will be an I frame encoded by intracoding or a P frame encoded by intercoding.

[0047] Next, the blocks of the compressed image frame are decoded with reference to the encoding methods of each block of the compressed image frame received in step 500, thereby generating an output image frame, in step 510.

[0048] If it is determined in step 520 that an error is detected from a specific block during the decoding of step 510, feedback error information is fed back to the encoder via a communication network, in step 522. Here, the feedback error information includes the loca-

tion of an erroneous block. As described above, it is preferable that the location of the erroneous block is set in units of 16 (pixels) × 16 (pixels) macro blocks. An error can be detected by various techniques according to the application field, for example, by reverse variable length coding (RVLC) as described above.

[0049] Finally, an image frame decoded in step 510 is output, in step 530. Figure 5 sequentially shows the feedback error information transmission procedure in steps 520 and 522 and the image frame outputting procedure in step 530. However, it will be understood by those skilled in the art, to which the present invention pertains, that these procedures can be performed in parallel.

[0050] According to the present invention, when an error is detected by a decoder, it is fed back to an encoder, and the encoder uses a technique of compulsorily intracoding an erroneous block and the search range of the block with reference to feedback information, thereby inhibiting error propagation which occurs in a digital image data communication system. Also, through this inhibition of error propagation, error can be restored or removed within a short period of time.

[0051] Embodiments of the present invention can be written in a program that can be executed in a computer system. Also, this program can be read from a recording medium and executed by a computer. The recording medium may be a magnetic storage medium (for example, ROM, floppy discs, hard discs, etc.), an optical reading medium (for example, CD-ROM, DVD, etc.), or a carrier wave (for example, transmission through Internet).

[0052] Up to now, the present invention has been described by taking a preferred embodiment. It will be understood by those skilled in the art, to which the present invention pertains, that various modifications to the present invention may be made without departing from the essential characteristics of the present invention. Thus, the described embodiments must be considered not from a standpoint of restriction but from a standpoint of explanation. The true technical protection scope of the present invention must be determined not by the above description but by the attached claims, and all differences within the equivalent range must be interpreted to be included in the present invention.

[0053] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0054] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0055] Each feature disclosed in this specification (including any accompanying claims, abstract and draw-

ings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0056] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

## 15 Claims

1. A method of processing transmission data to inhibit error propagation in a digital image data communication system, the method comprising:

(a) inputting (400) an image frame from an external source;

(b) checking (420) for feedback error information including the location of an erroneous block on a compressed image frame detected during decoding by a decoder, the feedback error information received via a communication network;

(c) if it is determined in step (b) that there is feedback error information, intracoding (424) an erroneous block, the location of which is included in the feedback error information, and its search range, which is referred to to encode the erroneous block using an intercoding method, among the image frame input in step (a), thereby constituting a compressed image frame; and

(d) transmitting (430) the compressed image frame constituted in step (c), via a communication network.

2. The method of claim 1, comprising: when the image frame input in step (a) is the first image frame in a specific sequence, encoding (412) the entire image frame using an intracoding method, to constitute a compressed image frame.

3. The method of claim 2, wherein the step (b) comprises:

when the image frame input in step (a) is not the first image frame in a specific sequence, checking (420) feedback error information including the location of an erroneous block on a compressed image frame detected during decoding by a decoder, the feedback error information received via a com-

munication network.

4. The method of claim 3, wherein the step (c) comprises:

(c) if it is determined in step (b) that there is feedback error information, intracoding (424) an erroneous block, the location of which is included in the feedback error information, and its search range, which is referred to to encode the erroneous block using an intercoding method, among the image frame input in step (a), while the remaining area is encoded by intercoding, thereby constituting a compressed image frame, and if it is determined in step (b) that no feedback error information is received, intracoding (422) block(s) selected by a predetermined method from among the blocks of the image frame input in step (a), and intercoding the remaining blocks, thereby constituting a compressed image frame.

5. The method of any of claims 1 to 4, wherein the error block location included in the feedback error information in step (c) is set in units of 16 (pixel)  $\times$  16 (pixel) macro blocks, and the search range in step (c) includes 16 pixels or 32 pixels in four directions on the basis of the erroneous block.

6. The method of any of claims 1 to 5, wherein the feedback error information in step (b) is associated with the image frame immediately preceding a current image frame.

7. A method of processing received data to inhibit error propagation in a digital image data communication system, the method comprising:

(a) receiving (500) a compressed image frame via a communication network;

(b) decoding (510) the compressed image frame received in step (a) to constitute an image frame;

(c) if an error is detected (520) at a specific block on the compressed image frame received in step (a) during the decoding in the step (b), sending (522) feedback error information including an error block location back to an encoder via a communication network; and

(d) outputting (530) an image frame restored in step (b).

8. The method of claim 7, wherein the error block location included in the feedback error information in step (c) is set in units of 16 (pixel)  $\times$  16 (pixel) macro blocks.

9. A computer-readable recording medium for recording a program which is executed in a computer for processing transmission data to inhibit error propagation in a digital image data communication system, the program comprising the steps of:

(a) inputting (400) an image frame from an external source;

(b) checking (420) feedback error information including the location of an erroneous block on a compressed image frame detected during decoding by a decoder, the feedback error information received via a communication network;

(c) if it is determined in step (b) that there is feedback error information, intracoding (424) an erroneous block, the location of which is included in the feedback error information, and its search range, which is referred to to encode the erroneous block using an intercoding method, among the image frame input in step (a), thereby constituting a compressed image frame; and

(d) transmitting (430) the compressed image frame constituted in step (c), via a communication network.

10. A computer-readable recording medium for recording a program which is executed in a computer for processing transmission data to inhibit error propagation in a bidirectional digital image data communication system, the program comprising the steps of:

(a) inputting (400) an image frame from an external source;

(b) when the image frame input in step (a) is the first image frame in a specific sequence, encoding (412) the entire image frame using an intracoding method, to constitute a compressed image frame;

(c) when the image frame input in step (a) is not the first image frame in a specific sequence, checking (420) feedback error information including the location of an erroneous block on a compressed image frame detected during decoding by a decoder, the feedback error information received via a communication network;

(d) if it is determined in step (c) that there is feedback error information, intracoding (424) an erroneous block, the location of which is included in the feedback error information, and its search range, which is referred to to encode

the erroneous block using an intercoding method, among the image frame input in step (a), while the remaining area is encoded by intercoding, thereby constituting a compressed image frame, and if it is determined in step (c) that no feedback error information is received, intra-coding (422) block(s) selected by a predetermined method among the blocks of the image frame input in step (a), and intercoding the remaining blocks, thereby constituting a compressed image frame; and

(e) transmitting (430) the compressed image frame constituted in step (b) or (d), via a communication network.

11. A computer-readable recording medium for recording a program which is executed in a computer for processing received data to inhibit error propagation in a digital image data communication system, the program comprising the steps of:

(a) receiving (500) a compressed image frame via a communication network;

(b) decoding (510) the compressed image frame received in step (a) to constitute an image frame;

(c) if an error is detected (520) at a specific block on the compressed image frame received in step (a) during the decoding in the step (b), sending (522) feedback error information including an error block location back to an encoder via a communication network; and

(d) outputting (530) an image frame restored in step (b).



FIG. 1A

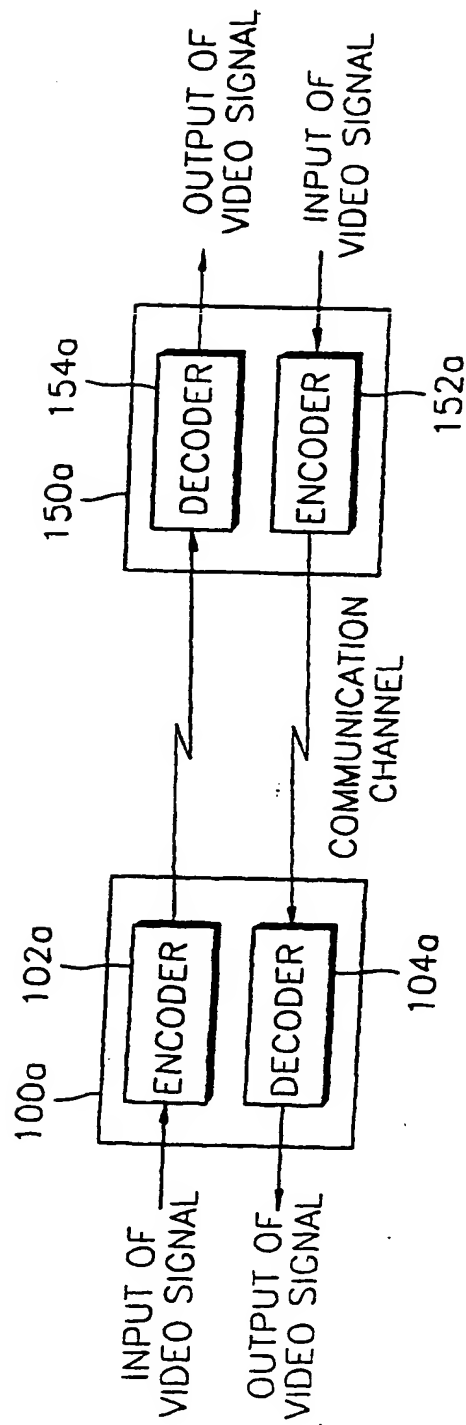


FIG. 1B



FIG. 2A

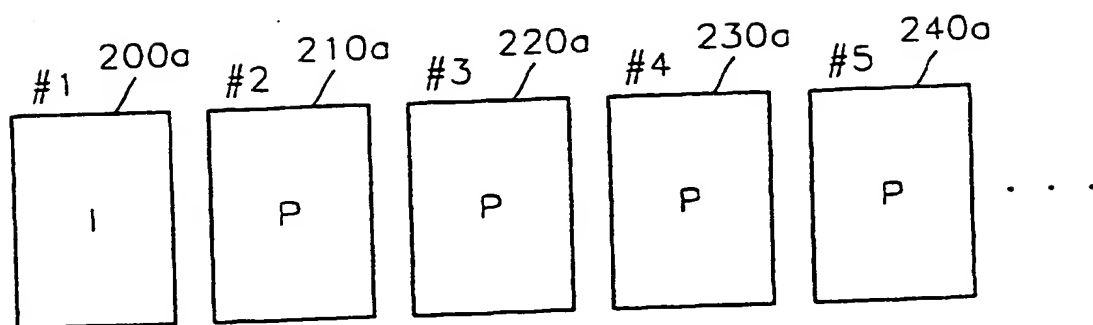


FIG. 2B

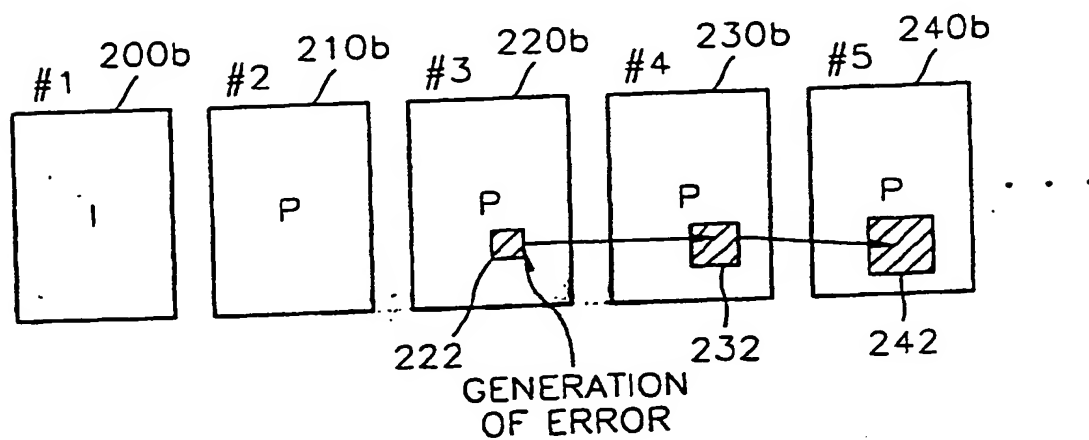


FIG. 2C (PRIOR ART)

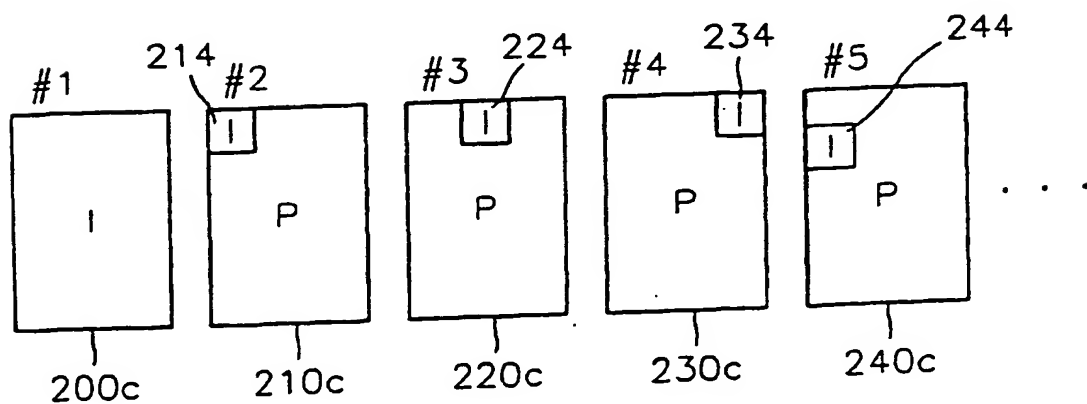


FIG. 3

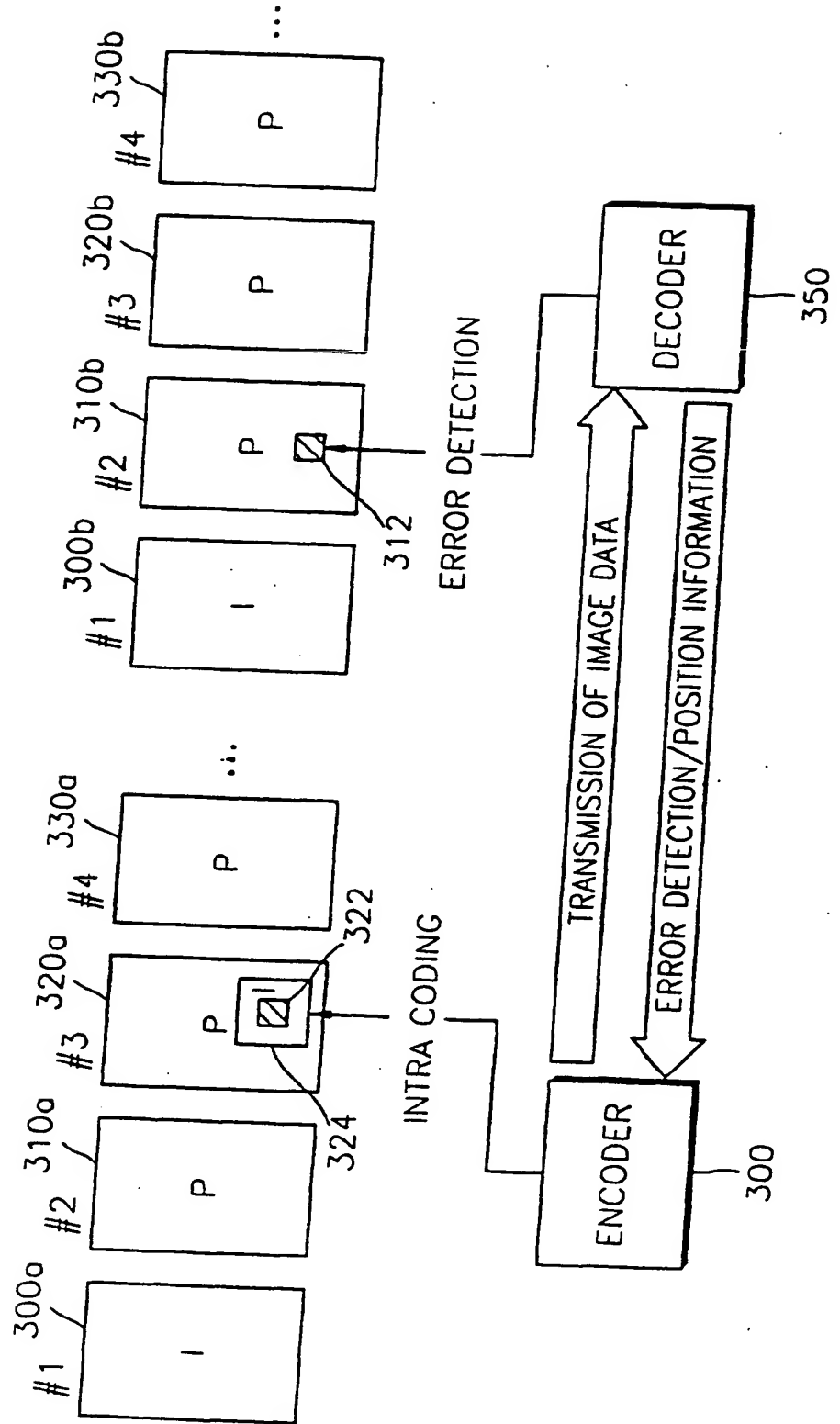


FIG. 4

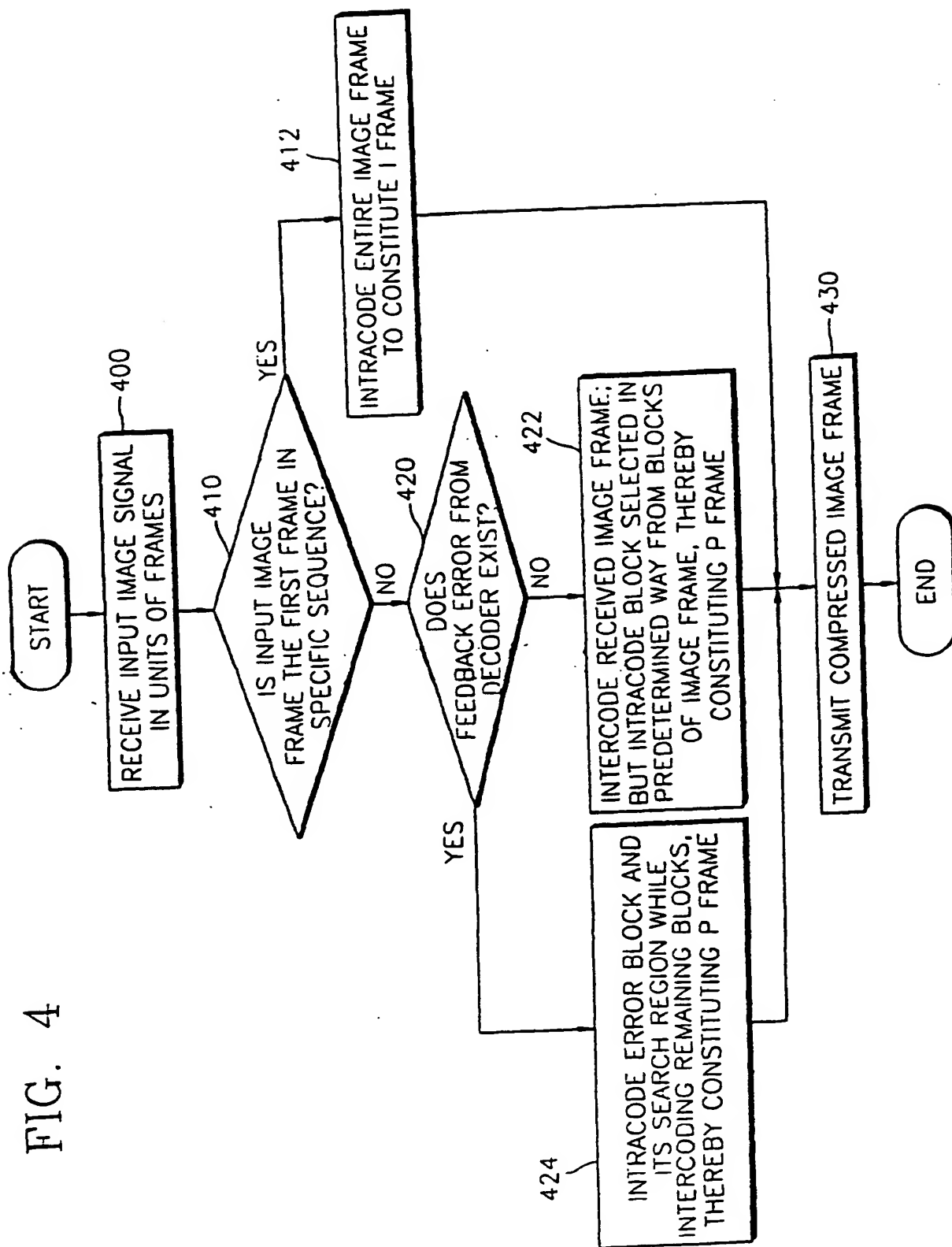
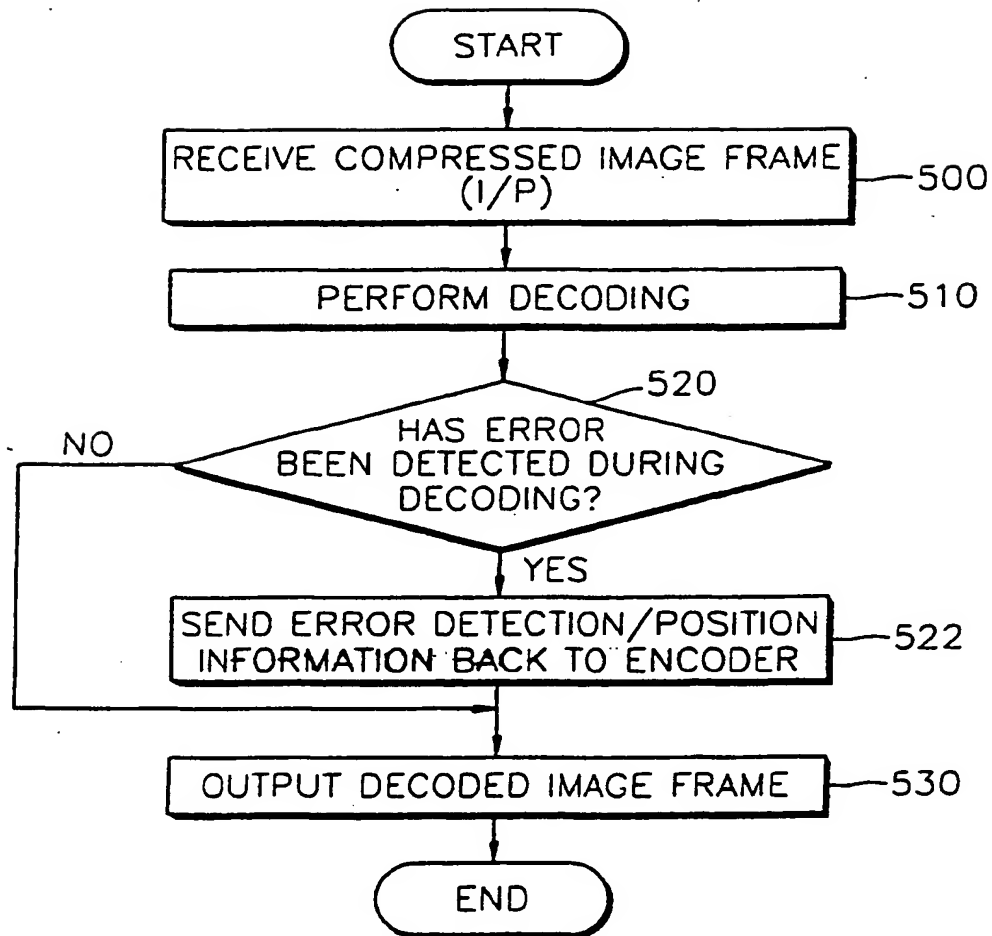


FIG. 5



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